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Empirical investigation of long-term interest rate determination

Jansen, P.W.

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7. Summary and conclusion

This book focuses on the empirical research on long-term interest rates. Section 7.1 summarises the key findings while section 7.2 discusses a few suggestions for future research.

7.1 Key findings

The key research problem that this book addresses is the empirical identification of the key factors that determine long-term interest rates in developed economies. In modern macro and financial economic literature there are several theoretical concepts in which the long-term interest rate is determined. However, these are *partial* theories, not an overall long-term interest rate theory. These theories are the following: classical demand and supply of capital, inflation expectation theory (Fisher), term structure theory, capital asset pricing model theory and the interest rate parity theory. These partial theories enable an identification of variables, which can be included in empirical research on long-term interest rates.

Nearly all included time series in the empirical research are stationary on level $I(1)$. Taking this into account, models are estimated with an error correction specification. This book contributes to economic literature through encompassing the partial theories in general models and a comparison of the relevance of the partial theories. The estimated error correction models (ECM) with quarterly data can explain between 46% and 67% of the interest rate changes for a set of twelve countries (United States, Japan, Germany, United Kingdom, France, Italy, Canada, Spain, Australia, Netherlands, Belgium, Switzerland) based on these five partial theories. The interest rate variables that are incorporated (the short-term and foreign long-term interest rate) have the highest explanatory power among the explanatory variables. Estimates with only the short-term interest rate and the foreign long-term interest rate can still explain 36% to 61% of the interest rate movements for the set of countries. However, non interest rate variables are still relevant for explaining long-term interest rate changes, especially for larger countries. Estimating with annual data leads to a similar conclusion: 62% to 88% of interest rate variability can be explained, somewhat better than with quarterly data and with fewer variables.

As a benchmark to the encompassed models both unstructured and structured time series models are estimated. The selected ARIMA and VAR models have a weak AIC information ratio, leading to the conclusion that the encompassed models are to be preferred over these benchmark models. The standard error of the ARIMA model (0.42) is almost equal to the encompassed model for the German long-term interest rate (0.44), but the explanatory power of this ARIMA model is much lower than the explanatory power of the encompassed model. The VAR model scores better on explanatory power, but has a much higher standard deviation than the encompassed ECM model.

In addition to the main research problem of long-term interest rate explanation, there are also three thematic issues addressed in this book: investigation of the causes of the low long-term interest rate in Japan, the impact of global economic integration on the influence of central banks on long-term interest rates and forecasting long-term interest rate rates.

In comparison with other countries, the long-term interest rate in Japan is much better explained by the current account balance. The low long-term interest rate in combination with high government debt and fiscal deficit is another reason to focus more specifically on Japan. One may wonder whether the Ricardian equivalence motive applies to Japan. The Granger causality test does not indicate that causality runs from the government savings to corporate or household savings. In addition to that, mainly corporate savings have increased and not household savings. It is probably not the size of net savings that has resulted in higher relevance for explaining long-term interest rates, but the relatively high t-value. What is different in Japan is that the domestic government bond market is financed to a much larger degree through domestic sources. The (semi)government and central bank hold a relative large share of the Japanese government debt. There also seems to be some evidence of a stronger home bias.

Global financial integration may have led to a higher synchronization between long-term interest rates worldwide and a weakened relation between the domestic short-term interest rate and the long-term interest rate. The empirical analysis shows that in the period 1980 to 2011 the foreign long-term interest rate has indeed been

more important for explaining long-term interest rate changes. This applies both to large and small countries, even though the results are slightly stronger for small countries. The relevance of the foreign long-term interest rate, when tested in isolation through rolling regressions, has risen between the early 1970s and the mid-2000s. Nevertheless, Granger causality tests cannot systematically confirm that causality runs from the foreign long-term interest rate to the home long-term interest rate for the group of twelve countries. When statistically significant causality is found, it often runs both ways.

The relevance of the domestic short-term interest rate has fallen between the 1980s and mid-2000s. The relationship between domestic and foreign short-term interest rates has increased, in particular since the 1990s. This seems to be a result of the integration of the global economic cycle, as also the relationship between economic cycle indicators has risen since the 1990s. This may potentially have important consequences for central bank policy. Global financial market integration may restrict a central bank in influencing domestic long-term interest rates, and consequently, influencing conditions for savings and investments in case of a country specific shock.

In addition to explaining long-term interest rate movements, forecasting models for long-term interest rates are compared in this book. Time series models (AR and ARIMA), macro factor models (structured interest rate equation and VAR) and expert based forecasts are compared individually and in combination for two time horizons (three months and twelve months) for a set of five countries (United States, Japan, Germany, United Kingdom, the Netherlands). The forecast models show that on a 3 month horizon the standalone models can hardly beat the random walk (which forecasts no change), when evaluated with the mean square forecast error (MSFE). Expert forecasts contain a structural bias, correcting for this, leads to a lower MSFE. Combining models leads to a lower MSFE, but it is still not possible to beat the random walk consistently on a 3 month horizon.

On a twelve month horizon the results of the AR time series model, structured interest rate equation and the expert forecasts are better relative to the random walk. The original expert forecasts outperform the corrected expert forecasts on this time

horizon. Also on the twelve month horizon the combined models lead to better results than the standalone models. The combinations with weights based on the in-sample MSFE and equal weights, where the original expert forecast and the structured interest rate equation are combined, outperform the random walk for all five countries and three countries, respectively. Of the three methods of combining forecasts (MSFE based weights, estimated weights and equal weights) the weights based on the in-sample MSFE yield the best performance in the outside sample period on both time horizons. In the combinations, the original expert forecasts yield better results with the macro factor model on both horizons. Nevertheless, by itself, the corrected expert forecasts lead to better hit ratios (correctly forecasted direction as a percentage of total forecasts) on both the three and twelve month horizon. The hit ratios are better on a twelve month horizon than on a three month horizon. This is also true for the structured interest rate model, which yields for both time horizons hit ratios of at least 50% on average. The hit ratios of the combined models are higher than those of the standalone models and are also higher on a twelve month horizon than three month horizon. For the twelve month horizon all six combinations (three combination techniques for each with the two variations of original and corrected expert forecasts) have hit ratios of above 50% in the outside sample period.

Much of the empirical research covers the period before the financial crisis/global recession of 2007-2011. Most models have a starting period between 1960 and 1980 and end in 2004. This leaves an outside sample period which consists of a relative quiet financial market period 2004-2006 and a volatile period 2007-2011. How have the models performed during the relative volatile period? Of the explanatory encompassed models the hit ratios are better in the crisis period versus pre-crisis outside sample period (72.6% versus 67.3%), indicating that the models are quite well specified to track the direction in which interest rates have moved in both parts of the outside sample period. Although from a hit ratio perspective the results appear to be strong, the standard deviation of the difference between the estimate and the actual interest rate changes is higher in the second part of the outside sample period, partially a result of a higher volatility of interest rates in this period. For the United States and Germany, which both fulfil a safe haven role, the interest rate level has been overestimated while for countries that came under pressure during the sovereign crisis, such as Spain and Italy, the level of interest rates are

underestimated. Although much of the volatility is picked up by the models, factors such as government bond purchases by central banks, safe haven flows and deterioration of credit standards are not included in the models.

The rolling regressions have shown that the influence of the foreign long-term interest rate has risen since the 1970s. However, the relation collapsed during the crisis. A reason for this could be that during the crisis government bonds were no longer perfect substitutes. The relationship with the short-term interest rate weakened initially as well, but improved soon after. The integration between economic cycle indicators rose to very high levels during the crisis, confirming the global character of the shock. The relevance of the foreign long-term interest rate may return after the crisis, once banking problems are resolved and investors are convinced of the return of sustainable government finances.

With regards to the forecast models the MSFE of the random walk is higher during the crisis period of the outside sample period relative to the first part of the outside sample period, particularly for the three month forecast period. However, the MSFE increase of the estimated models is less than that of the random walk. Therefore, the performance in the outside sample period is better for the three month horizon relative to the random walk. On the twelve month horizon the expert based, macro factor based and combined models perform poorer relative to the random walk. The hit ratios are better in the volatile period for most models on both time horizons, which is probably again a result of higher volatility. Also with regards to the forecast models it is concluded that a large part of the higher volatility is picked up by the models, and particularly the three month performance has improved. Nevertheless, the total outside sample conclusion that the combined models outperform the standalone models and that the performance of combined models relative to the random walk is better on a twelve month horizon is also confirmed during the crisis period of the outside sample period.

7.2 Suggestions for future work

Research in this book focuses on factors that determine long-term interest rates, with a focus on twelve industrialised countries. At the end of the period over which the research for this book has been conducted, the risk free characteristics of

government bonds have become a relative concept, rather than an absolute concept. The variations in risk characteristics of government bonds between countries have increased as a consequence. For that reason, researching diverging risk premia could be an interesting approach. Also dynamic models that identify regime changes may be useful in identifying which variables and theories are more relevant in differing financial market and economic circumstances.

Even though the long-term interest rate is a central theme in economic literature, theory lacks an overall long-term interest rate theory. This book identifies a number of partial theories that discuss aspects of long-term interest rate determination and suggests where the theories can be connected. However, future work could build further on this to establish a formal long-term interest rate theory.

The empirical analysis of this book discusses interest rate formation in twelve industrialised countries. These countries are divided in *large* and *small* to compare results for the relative large versus smaller countries. This could be developed further, through incorporating more countries, and using different definitions to determine whether a country belongs in the “large” or “small” group. Also with respect to countries, in line with the increasing importance on financial markets and in the world economy, it would be interesting to incorporate emerging economies in the analysis as well.

With regards to specific variables that are used in this book it would be beneficial to explore further the expected inflation premium, since only limited evidence is found with realized inflation data. With regards to equities, for which a valuation measure (P/E) is used, equity performance measures could be analysed.

This book finds a significant explanatory power for interest rate variables and some explanatory power for non-interest rate variables. To be able to incorporate more economic cyclical information, models could be estimated with a monthly frequency. In addition to that, economic growth surprises could perhaps identify the impact of economic data on long-term interest rates even better. Perhaps estimating with monthly data would capture the business cycle data better.

The combination of forecast models for long-term interest rates indicates that forecast errors can be reduced. This can be explored further. A research project combining model based and consensus forecasts with forecasts from technical analysis may show how much additional information, if any, technical analysis provides for improving interest rate forecasts. The latter may particularly improve the forecasting ability on a shorter time horizon, where it seems particularly difficult to beat the random walk. Also, the short-term forecasts may benefit from including economic growth surprises and indicators specifically designed to track changes in economic momentum. Finally, short-term forecasting models for long-term interest rates may also benefit from other factors that drive interest rates, such as capital flows into asset classes and surveys on investor positioning or market volatility measures (as a proxy for risk aversion).